

SPECIAL COMMITTEE ON AGING
UNITED STATES SENATE

Hearing On:

Assistive Technology for Aging Populations

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Statement of:

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Mr. Chairman and Members of the Committee:

Good morning. My name is Martha Pollack and I am a Professor of Electrical Engineering and Computer Science at the University of Michigan, where I conduct research on the design and assessment of assistive technology for older adults. I want to thank you for holding a hearing on this important topic.

As your committee knows, our nation is facing an enormous challenge as a result of the dramatic demographic shift underway. According to U.S. Census Bureau projections, by 2030 approximately one in five Americans will be elderly, compared to one in eight today, and this increase will continue through the first-half of the century [1]. As senior citizens come to constitute a greatly increased proportion of our population, we have to ask how we will assure their care. How will we enable them to meet the range of challenges that they may face as a result of their increased likelihood of having physical, sensory, and cognitive deficits?

Today, I want to describe to you some advanced technologies that have the potential to help elders meet those challenges. Let me be clear: technology is not a panacea, and it will never—and should never—replace human caregiving. But when used to *supplement* human caregiving, advanced technologies that are now emerging in the laboratory have the potential to greatly improve the quality of life for older adults and their caregivers. This technology can increase the autonomy of our senior citizens, and in particular, enable them to “age in place”, that is, remain living in their homes for longer periods of time. A large body of research has shown that older Americans prefer to maintain independent households as long as possible [2], and indeed, 95% of our elders live in

private residences [3]. Additionally, institutionalization has an enormous financial cost, for elders and their caregivers, as well as for the U.S. Government, which under the auspices of Medicaid and Medicare, pays for nearly 60% of the nation's \$132 billion annual nursing home bill [4]. Thus technology that can help seniors live at home longer provides a "win-win" effect, both improving quality of life and potentially saving enormous amounts of money.

Devices that compensate for physical and sensory deficits have been developed for a number of years. These range from low-tech artifacts that are in wide use, such as lift-chairs and ergonomic door-handles, to more technically sophisticated, but higher cost, systems now available on the market, such as text-to-speech systems for people with low vision and digital programmable hearing aids. In addition, there are futuristic devices still in the laboratory, such as obstacle-avoiding wheelchairs [5, 6] and devices that allow people with limited mobility to control household appliances using simple hand gestures [7].

Yet some of the most exciting and promising advances involve technology that can help older adults compensate for cognitive decline. While we now know that severe cognitive impairment is not a part of normal, healthy aging, we also know that aging does affect certain cognitive processes [8, 9]. Additionally, of course, the major dementing illnesses that lead to severe cognitive impairment are much more prevalent amongst older adults than younger ones. Assistive Technology for Cognition (ATC) can help cognitively impaired people in one or more of the following ways:

- by *monitoring* their functional activities in order to provide feedback to their caregivers,
- by *assessing* their cognitive status, and
- by *assisting* them in the performance of their daily activities.

Let me briefly describe to you examples of ATC systems intended for each of these goals; more extensive surveys can be found elsewhere [10, 11].

Monitoring systems aim primarily at ensuring safety and well being, and at reducing caregiver burden, by tracking an elder's behavior and providing up-to-date reports to his or her caregiver. Early examples of such systems include personal alarm systems that enabled elders to summon help by pushing a button. The best known of these is Lifeline (formerly LifeCall), whose advertisements made famous the catch phrase: "Help; I've fallen and I can't get up". Technology has advanced significantly since then, and today monitoring systems deploy networks of sensors installed in an individual's home to automatically track an elder's activities. The network may include environmental sensors such as motion detectors and RFID readers that determine where a person is, contact switches on cabinets and refrigerator doors that indicate whether they've been opened, and pressure sensors in beds and chairs. It can potentially also include biosensors worn by a person to measure vital signs such as heart rate and body temperature. The collected sensor data is continually monitored both to determine deviations from normal trends that may indicate problems (e.g., failure to eat meals regularly, as determined by lack of motion in the kitchen) and to detect emergencies that require immediate attention (e.g., falls, as indicated by cessation of motion above a certain height). Caregivers can get

status reports on a regular basis, typically by checking a web page, and are also alerted to emergencies by phone, pager, and/or email. Examples of advanced monitoring systems include research projects [12, 13, 14, 15, 16], a demonstration system being used in an elder-care residential setting, which will be described by another participant in this hearing [17], and a handful of commercially marketed products.

There has been less work done to date on the second use of assistive technology for cognition, which involves *assessing cognitive status*. Typically, when a person needs to be evaluated for cognitive impairment, the evaluation is done in a formal medical setting, such as a psychologist or occupational therapist's office. In contrast, with advanced technology, one can potentially perform such assessment in a person's home, while they perform everyday activities, over an extended period of time. This may produce more accurate assessments, and it may also enable early identification of cognitive changes in at-risk patients. An example of project that is investigating the use of technology for assessment is now underway at the National Rehabilitation Hospital. In this project, sensors are being placed in a kitchen in which patients will perform everyday tasks such as making tea. Studies are being conducted to determine whether performance metrics based on data gathered from the sensors provide good indications of level of cognitive functioning [18]. (In the pilot study, the kitchen is on hospital grounds, but later phases of the study will evaluate system utility in actual homes.) Similar projects are also underway elsewhere [19, 13].

The third main use of assistive technology for cognition is to provide guidance to people as they carry out their daily activities. For example, *activity-cueing systems* guide people through multi-step activities such as bathing or simple meal preparation, issuing cues to perform each successive step in the activity. Activity-cueing systems may be particularly beneficial to people with severe cognitive impairment. For instance, the COACH system [20, 21] is designed for people with moderate to severe Alzheimer's disease. It guides its user through the process of handwashing, providing cues whenever a step such as soaping, rinsing, or drying is forgotten or is done in the wrong order. To decide whether a cue is needed, the COACH system relies on information from a sensor network specially designed for the washroom, interpreting that information using Artificial Intelligence (AI) techniques.

Activity cueing may also be helpful for less severely impaired people. An interesting example is the Cook's Collage, a system currently under development [22]. The Cook's Collage is a video-based system that records a person's activities as he or she cooks a dish, selects frames from a video that represent the previous six steps taken, and displays these on a monitor, so that the user can check to see what has just been done. This might be important if, for instance, he or she is temporarily distracted from the cooking task by a telephone call. Advanced image-understanding techniques are needed to interpret the video stream and map individual video frames to logical steps in the cooking task.

Where activity-cueing systems provide reminders about multiple steps in a single action, *schedule-management systems* instead provide individual reminders about multiple activities, in the context of a daily plan. That is, they remind people when to take their medicine, when to eat meals, when to take care of personal hygiene, when to check in with their adult children, and so on. Early schedule management systems used alarm clocks, calendars and buzzers, [23, 24, 25], while later studies employed pagers, cell phones and palmtop computers [26, 27, 28]. Regardless of the delivery platform, these early systems—like most commercially available reminder systems today—function like glorified alarm clocks: they issue fixed reminders for activities at pre-specified times. Unfortunately, this greatly limits their effectiveness, because older adults, like younger ones, do not live their lives according to ironclad, unchanging schedules. To be useful, schedule-management systems need to be much more flexible.

Let me illustrate what I mean by describing an advanced schedule-management system called Autominder that my students and I have been developing at the University of Michigan [29, 30, 31]. Autominder can either run on a mobile robot such as Pearl, who we have brought with us to this hearing, or on a handheld computer, which can potentially be connected to the kind of sensors that I described earlier. In the future, we hope also to present reminders on “wearable computers” such as wristwatches or pendants. In all cases, the interface is very simple, consisting simply of reminders that are either displayed textually on a screen or spoken aloud by a synthesized voice.

Consider how Autominder is being designed to interact with an older adult like Claire, a forgetful, 80-year-old diabetic woman, who is supposed to eat a meal or snack every four hours, and who currently has an infection that requires her to take antibiotics on a full stomach. We don’t tell Autominder that Claire has to take her medicine at, say 8a.m.; instead, we tell it that she has to take the medicine at the same time as she eats breakfast and dinner. Then, whenever Autominder recognizes that Claire is eating breakfast, it will remind her to take her medicine if she forgets to do so. Similarly, we don’t tell Autominder that Claire has to eat at, say 7, 11, 3, and 7; we just specify the 4-hour interval. If Autominder sees that Claire ate lunch at 11:15 (say, because it received information from the sensors saying that she opened the refrigerator, put something in the toaster, and opened and closed the cabinet where she keeps her dishes), then it will remind her to eat again at 3:15—or maybe a little earlier if her favorite TV show is on from 3:00 to 3:30. To achieve this kind of flexibility, we are using a variety of Artificial Intelligence techniques in Autominder; these enable it to model an elder’s plan, to track the plan’s execution, and to reason about whether and when to issue reminders.

I want to describe to you one final example of assistive technology for cognition, because so far all the examples I have given have focused on problems arising from memory decline, but there are other types of cognitive impairment that can affect older adults. IMP, which we will demonstrate at the end of my oral comments, is designed for people who have problems with orientation. Although IMP is a walker, and thus suitable for use by people with motor problems, it is primarily a cognitive aid. Developed at Carnegie Mellon and the University of Pittsburgh, IMP has a very simple interface that allows a person to select the location to which he or she wants to go, and then just follow a

shifting red arrow to get there. IMP would potentially be particularly useful for residents of assisted living facilities who have a hard time navigating to the dining room, gift shop, exercise room, and so on. Like Autominder, IMP relies heavily on artificial intelligence technology, which it uses to compute the orientation of the arrow as the user walks along [32]. Other technologically sophisticated devices that help a person compensate for disorientation include the Activity Compass, a Palm pilot-based system intended for people with early Alzheimer's disease. The Activity Compass uses GPS to learn a model of its user's routine travel behavior, predict likely destinations, and suggest routes should the user become lost [33].

As I hope these examples have illustrated, there is very good reason to believe that technologies now under development can help us meet the coming crisis in elder-care. But significant technological challenges remain to be met, most notably in four key areas:

1. Much of the emerging technology relies heavily on *sensing technology*, and there will need to be fundamental advances in using wireless sensor networks to track and measure activities of daily living. We are really just beginning to understand how to design sensor networks that are reliable, secure, and easy to install and maintain—and we are even less far along in understanding how to use the information we can obtain from those networks to recognize everyday activities.
2. To be useful to older adults, assistive technology needs to be flexible and adaptive. Extensive customization for each user will be economically infeasible, and thus the systems we design need to be “self-tuning”. Advanced computational techniques, and in particular, *Artificial Intelligence techniques*, need to be developed to make these systems work.
3. Even the most powerful system will fail if its intended users cannot interact with it. Research into *human-computer interaction* must be pursued to develop interfaces that are extremely easy to use by people who may not only be cognitively impaired, but may also have visual, auditory, and/or motor difficulties.
4. Because much of the technology under consideration involves observing a person's everyday activities, crucial *privacy concerns* arise, and it is imperative to address these from both the technological and the policy perspectives.

In short, there is foundational work still to be done to realize the promise of assistive technology for older adults, and it is work that must be done by multi-disciplinary teams that include not only computer scientists, roboticists, and electrical and mechanical engineers, but also psychologists, physicians, nurses, occupational therapists, privacy experts, and representatives of the family-caregiving community.

Currently, federally sponsored research support for the design of this class of technology is patchwork, and it can be difficult to find sufficient funding because the work tends to “fall between the cracks” of agencies like the National Science Foundation, which

supports scientific and engineering research, but not clinical trials, and the National Institutes of Health, which traditionally have not funded computer science. To ensure that the foundations are put in place so that assistive technology will be ready by the time we, as a nation, need it, I would propose to this committee that they explore the possibility of developing a cooperative funding mechanism to provide a stable source of support for research on assistive technology for an aging population. This could plausibly involve a joint program of the NSF and either the National Institute on Biomedical Imaging and Bioengineering or the National Institute on Aging.

I feel very fortunate to be working on a topic that can potentially have such significant societal benefit, and I feel fortunate to be working on it at a major public research university that is as well-regarded as the University of Michigan, where I am able to interact on a daily basis with expert faculty and talented students from the many disciplines that must work together to make the promise of assistive technology real. I look forward to continuing to work in this area, and to the day that this technology is in wide use, helping older adults live better lives.

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